



MIT-Bates South Hall Ring as a Potential THz Coherent Synchrotron Radiation Source

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Workshop on Free Electron Laser Applications for
Biology and Medicine

Collaboration

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Outline

- Terahertz Coherent Synchrotron Radiation (CSR) in storage rings
- MIT-Bates South Hall Ring: unique for storage ring CSR research
- SHR low momentum compaction lattice operation experience (Dec. 2004, June 2005)

Coherent Synchrotron Radiation

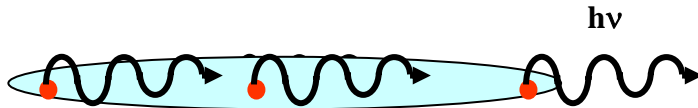
$$\frac{dP}{d\omega} = \frac{dp}{d\omega} \left[N + N(N-1)g(\sigma_l) \right]$$

Incoherent

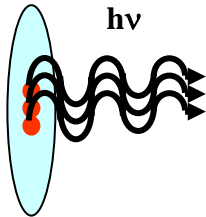
Coherent

Form factor:
FT of bunch
long. density

◆_s > ● incoherent emission



◆_s < ● coherent emission



Wave length limits:

- **Bunch length and distribution**--
Short wavelength cut off
- **Vacuum Chamber shielding** --
Long wavelength cut off

For Gaussian bunches and parallel plate mode:

$$\pi\sigma_s < \lambda < 2h \left(\frac{h}{\rho} \right)^{1/2}$$

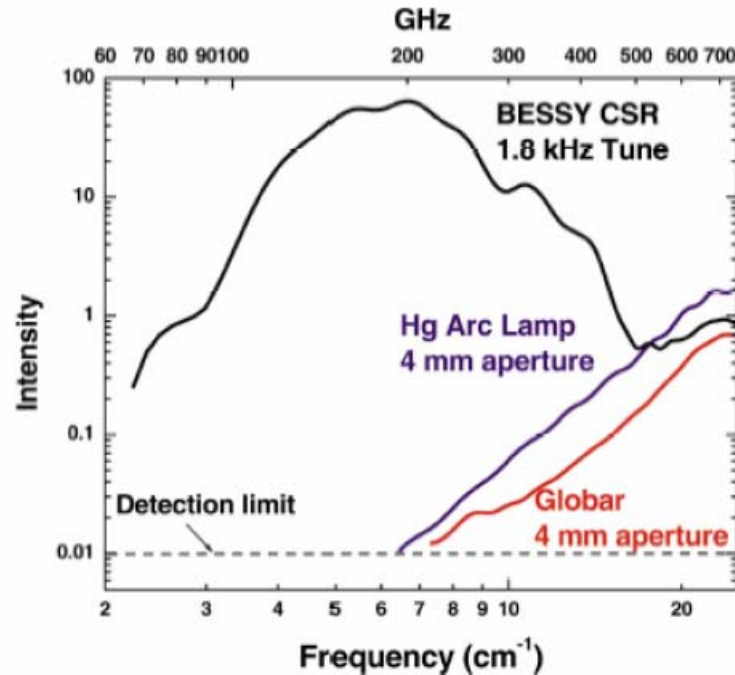
h: Vacuum chamber total height

ρ: Bending radius

High power, broadband e-beam based sources

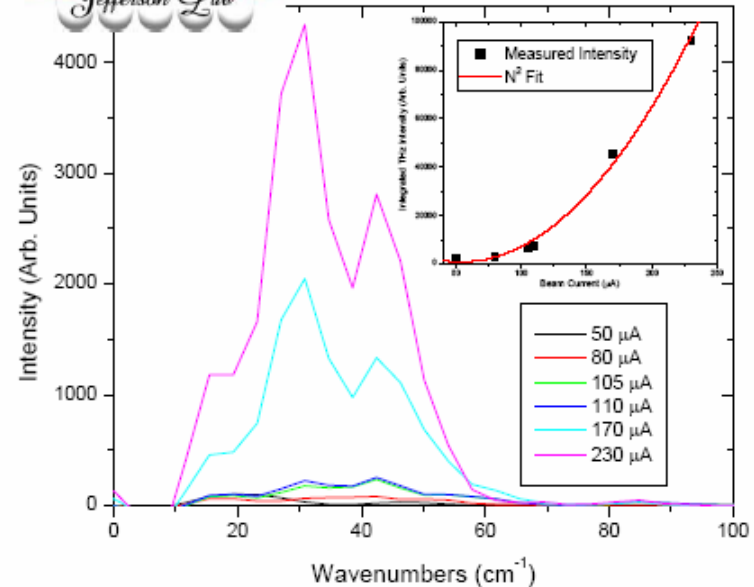


Storage Ring



M. Abo-Bakr et al., Phys. Rev. Lett. 88,254801(2002)
E.J. Singley et al., Physics Review B 69, 092512 (2004)

Energy Recovery Linac



L. Carr et. al., Nature 420, 153(2002)
G. R. Neil, G.P. Williams, Infrared Physics & Technology 45(2004) 389

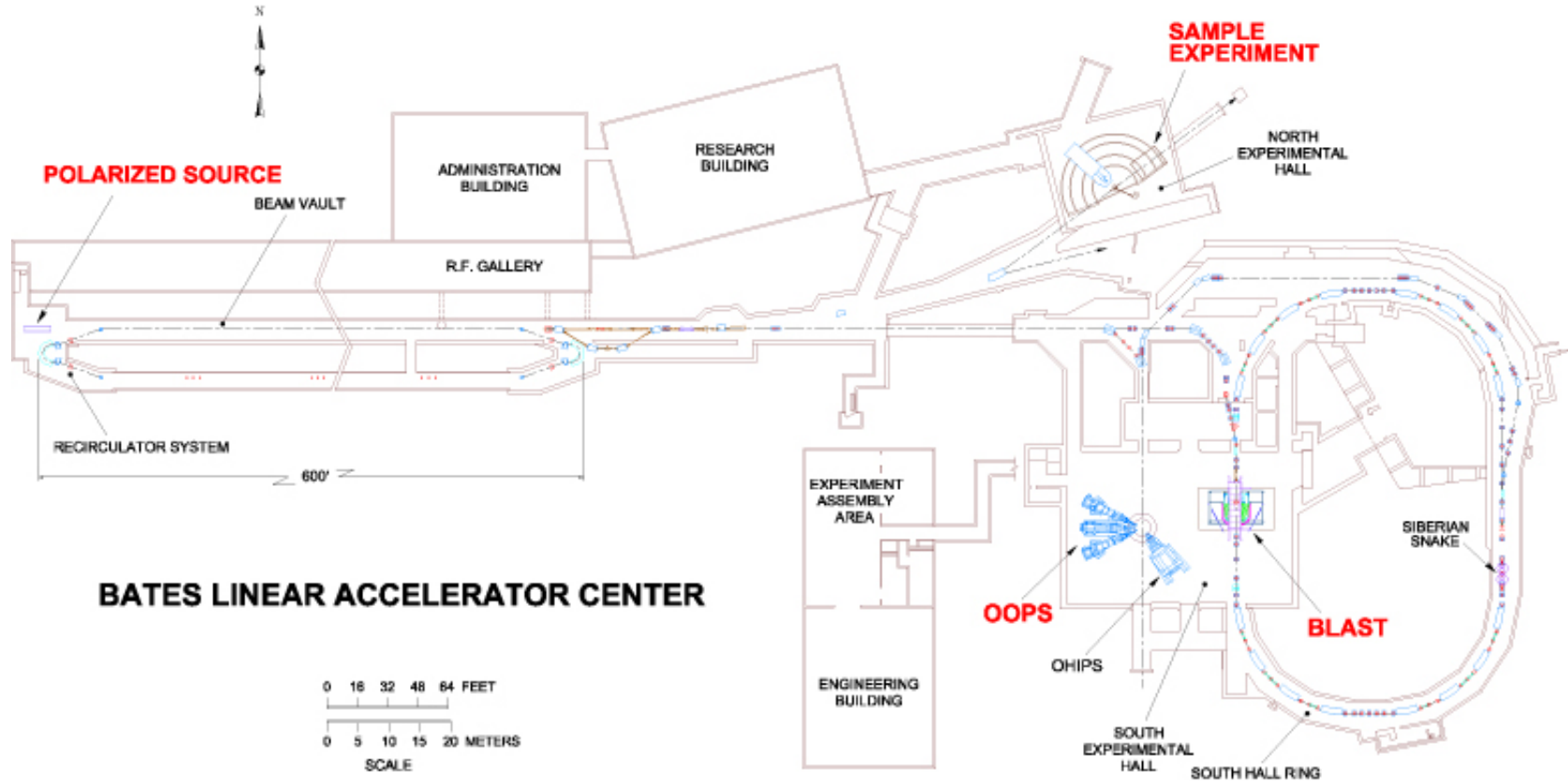
More stable ring THz operating sources: ANKA Germany, NewSUBARU Japan, ...

& planned: CIRCE/LBL, Metrology Light Source(MLS) Germany, SOLEIL France, DAΦNE Italy,...

MIT-Bates Linear Accelerator Center

- Use as national user facility for nuclear physics has ended with very successful completion of BLAST program studying the internal structure of the proton and neutron
- MIT has successfully completed negotiation with DOE in which MIT will take possession of the accelerator facility
- DOE will support Research & Engineering Lab at Bates, but not interested in the accelerator
- MIT now looking for new uses for the accelerator

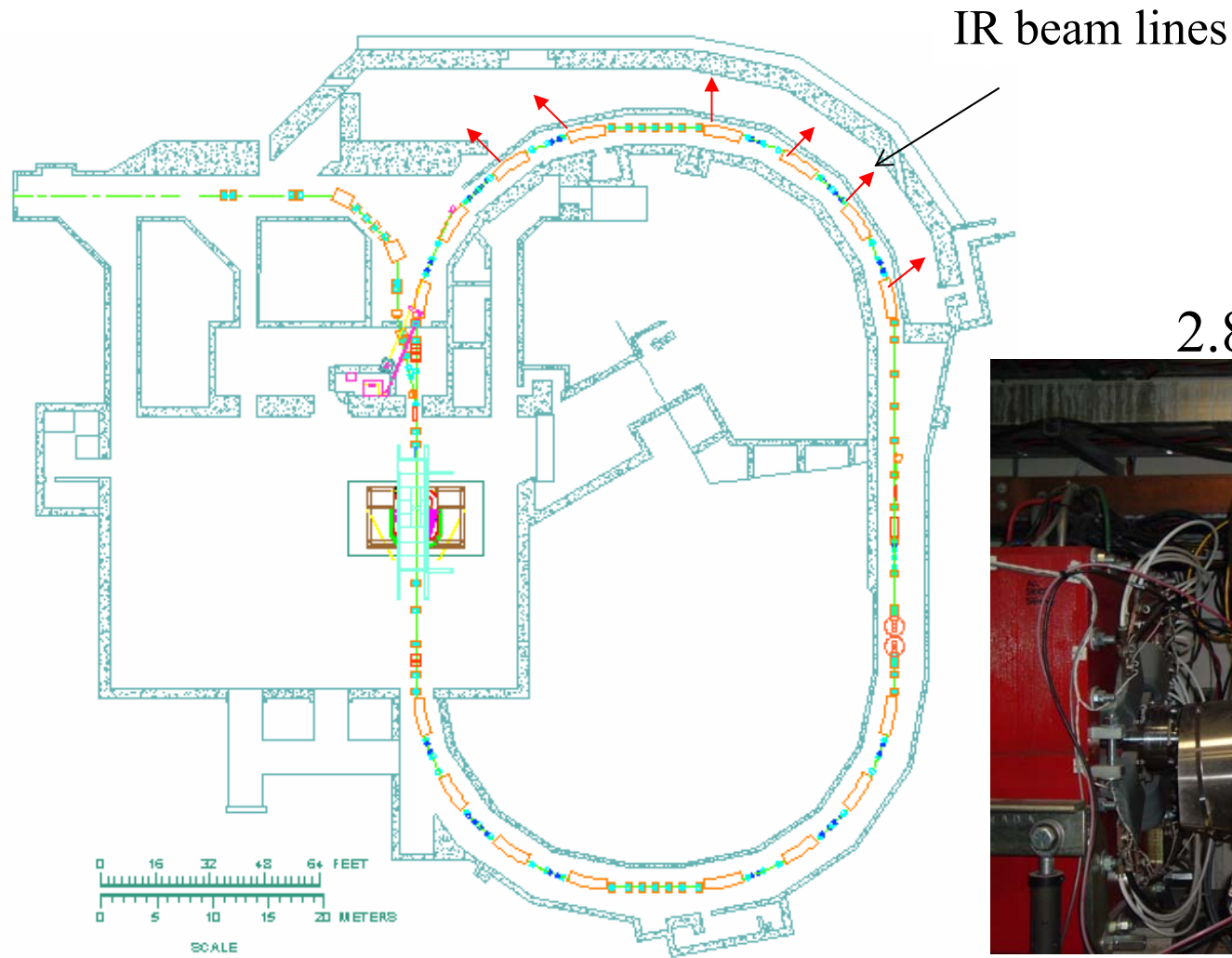
MIT-Bates Accelerator Complex



South Hall Ring: capability for CSR research

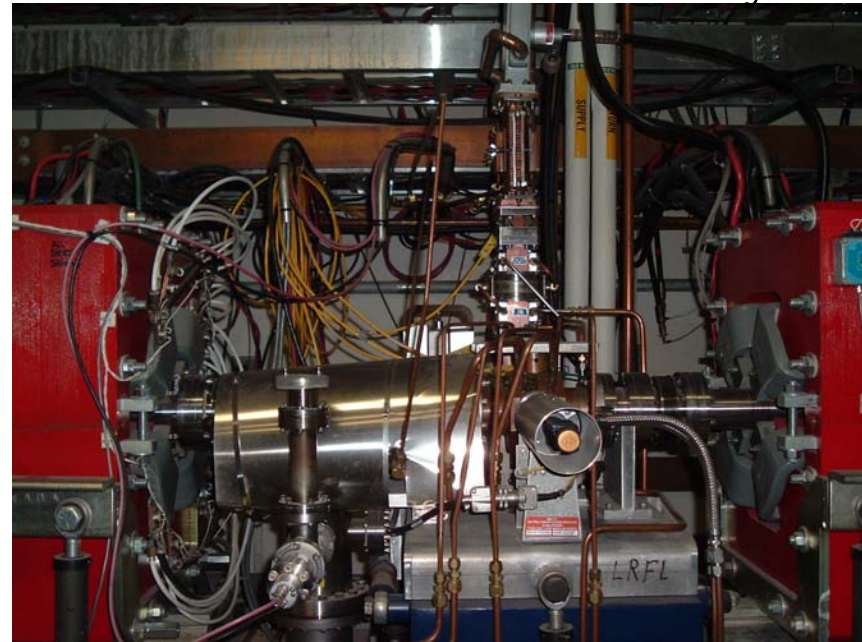
- Energy: 0.4-1.0 GeV; full energy injection into South Hall Ring
- Unique 2856 MHz single cavity RF system, routine operation: 200-300 mA
- Ring circumference 190.2m, long straights, flexible lattice structure, 16 bending magnets: radius=9.144 m, gap=7.62 cm
- Ample floor space available for IR beam lines

Floor Space for Potential IR Beam lines

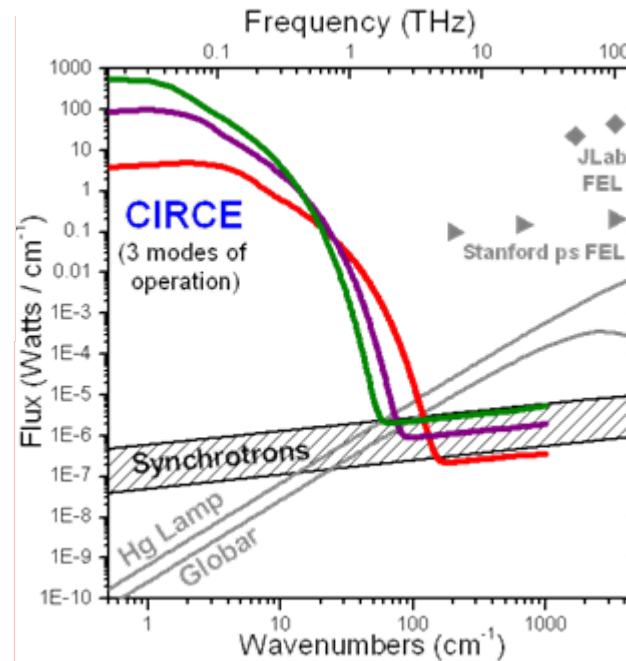
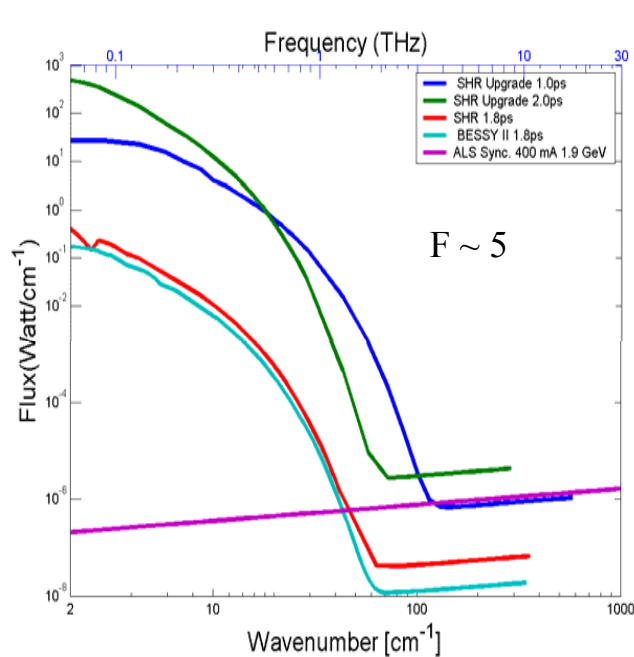


$$\sigma_L \propto \left(\frac{\alpha}{f_{rf} V_{rf}} \right)^{1/2} \gamma^{3/2}$$

2.856 GHz RF Cavity



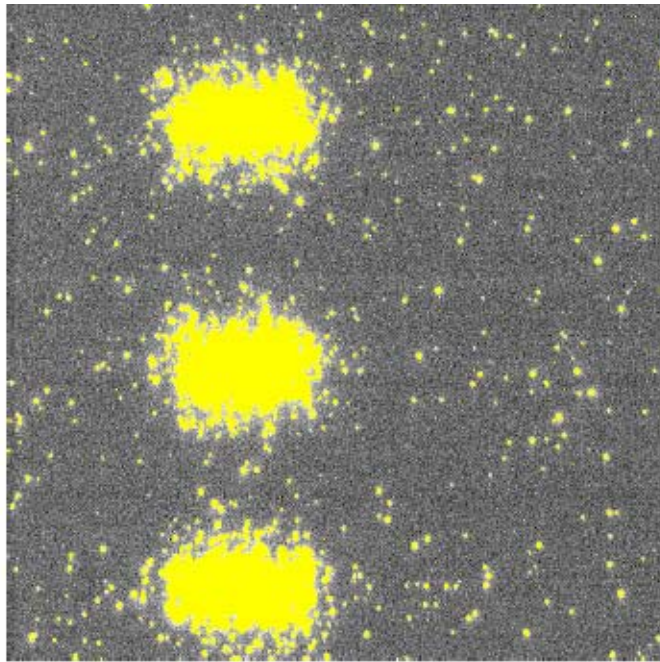
Calculation of SHR THz Spectrum: present and anticipated



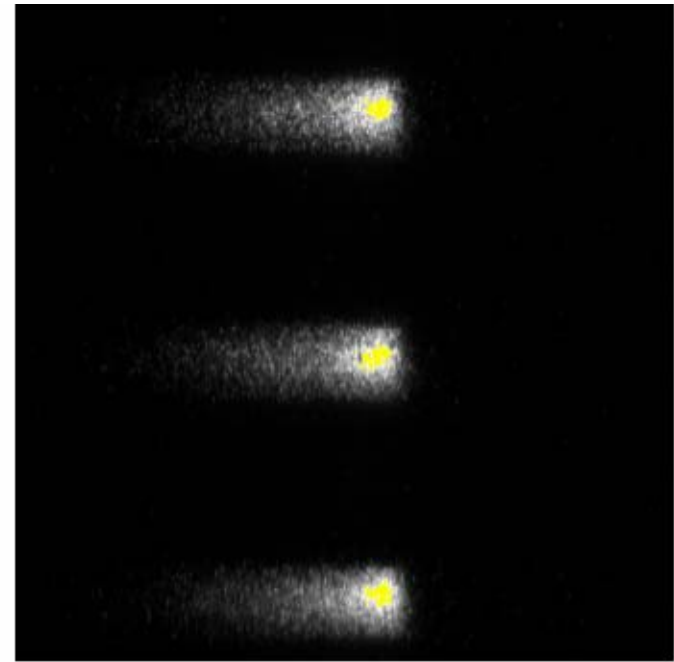
Ring	E (GeV)	R (m)	f_{rf} (MHz)	V_{rf} (kV)	L (m)	Hor. Accept. (mrad/port)	Bunch length σ (ps)
SHR	0.6	9.144	2856	140	190.205	60	1.8
SHR-upgrade	0.6	1.335	2856	1500	190.205	300	1,2
CIRCE	0.6	1.335	1500	1300	66	300	1,2,3
BESSY II	1.19	4.361	500	1300	240	60	1.8
ALS	1.9	4.957	476	400	196.8	60	

SHR Low momentum compaction Lattice operation experience (Dec. 2004)

SHR Bunch Longitudinal profile from Streak Camera (C6860)



“BLAST (original)”

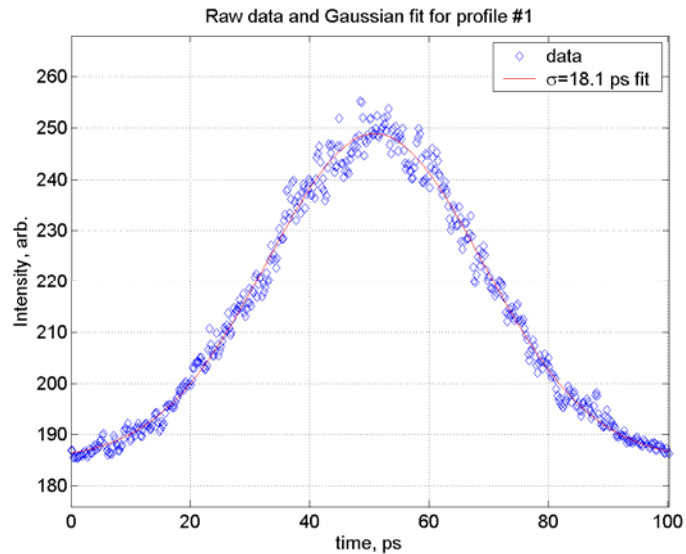


“LMC-4”

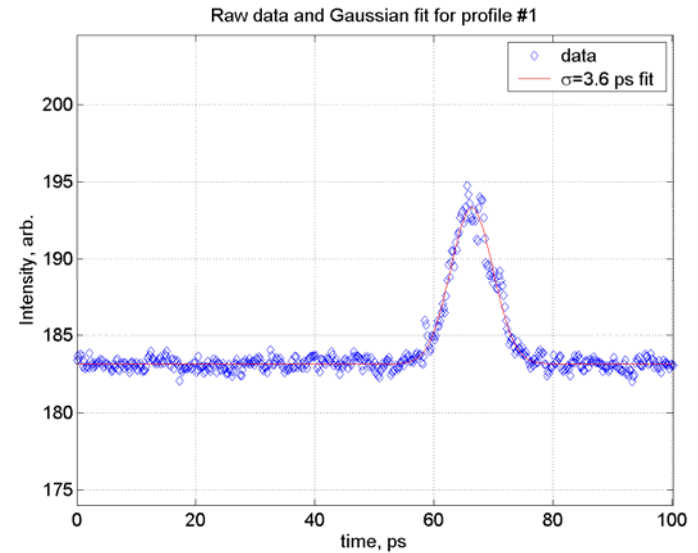
Synchroscan f: 81.6 MHz (2856/35), integration time ~ 100 ms

Bunch length ($V_{\text{rf}}=134\text{kV}$)

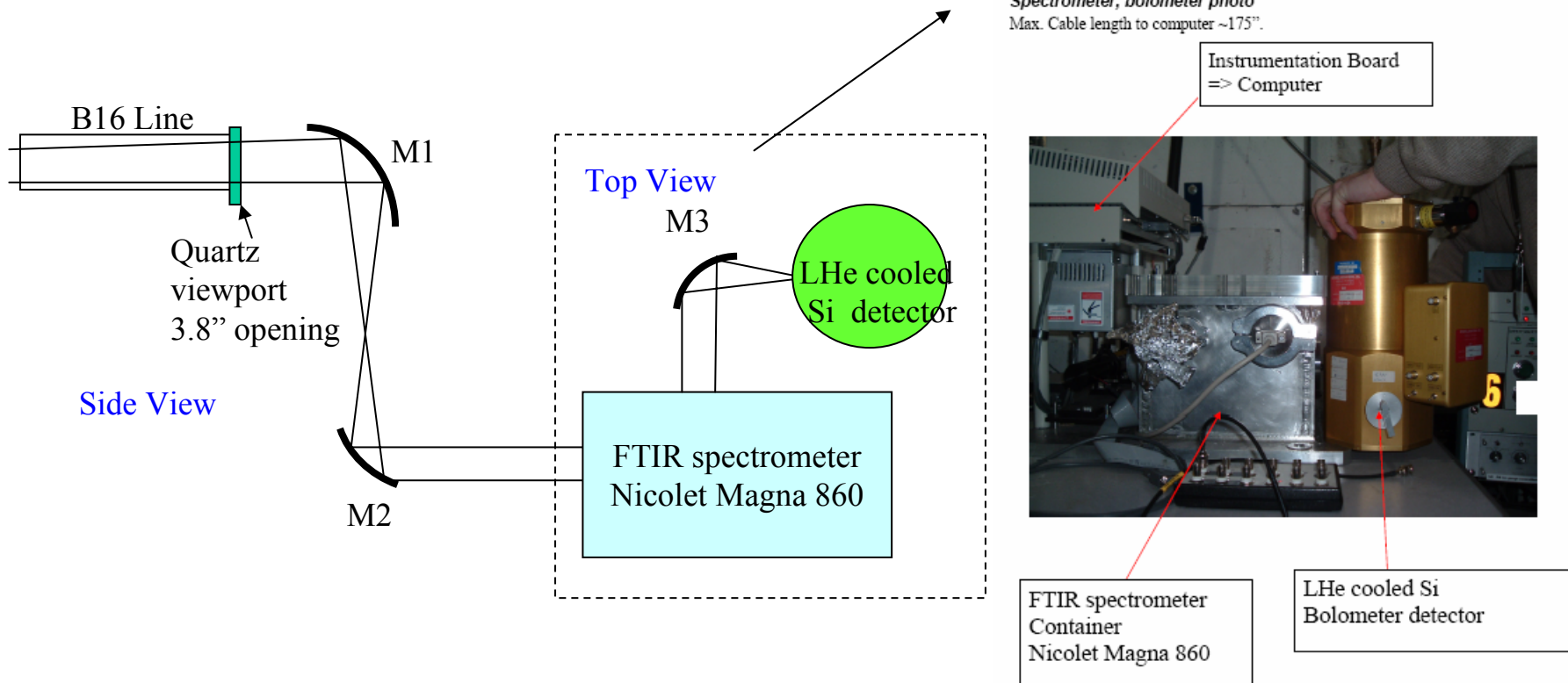
“BLAST”



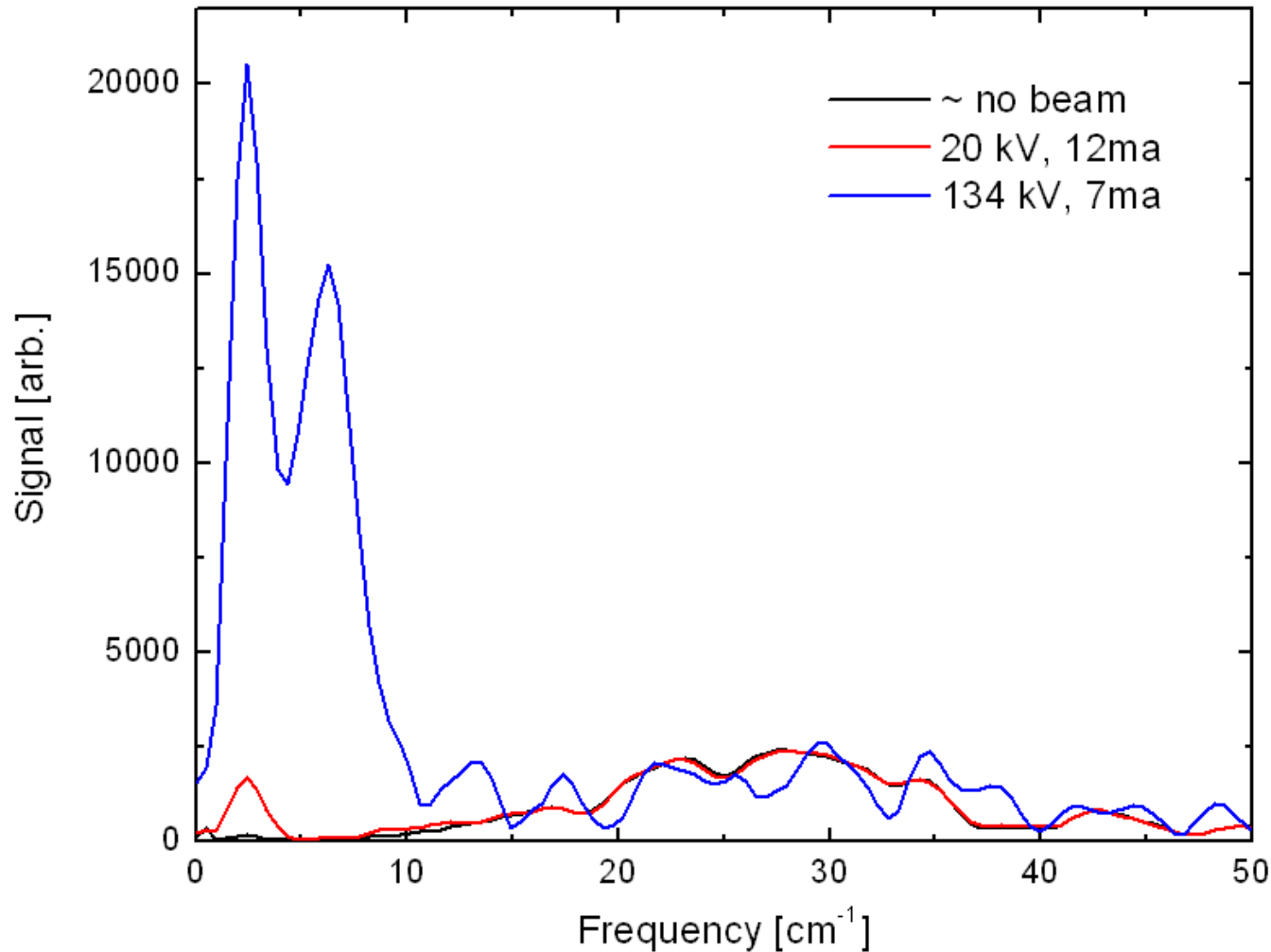
“LMC-4”



CSR Power & spectrum measurement (June, 2005)



CSR Power & spectrum measurement (June, 2005)



Preliminary:
6/6/05

Summary

- CSR has been observed in Bates SHR:
peak intensity in 0.1-0.3 THz range
- Short beam pulses:
<6ps FWHM, or 3.5 – 4 ps rms
- Working to shorten pulses, thus producing
higher frequencies
- Seeking users to develop capability